THE ENGINEERING TITLE ACT STUDY: THE PRACTICE/TITLE ACT DISTINCTION AND PROTECTION OF THE PUBLIC HEALTH, SAFETY AND WELFARE

EXECUTIVE SUMMARY OF SIGNIFICANT FINDINGS AND RECOMMENDATIONS

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In defining the Title Act Study in SB2030, the California Legislature specified a series of tasks that, together, would lead to recommendations for change in licensing the state's engineers. These tasks included:

- Meeting with representatives of the engineering branches and other professional groups.
- Examining the types of services provided by different branches of engineering.
- Reviewing and analyzing educational requirements for the separate engineering disciplines.
- Identifying the amount of overlap between engineering disciplines.
- Reviewing alternative methods of regulation in other states and assessing the impact these regulations would have if adopted in California.
- Describing the manner in which local and state agencies utilize regulations and statutes to regulate engineering work.
- Recommending changes to existing laws regulating engineers after considering how these changes may affect the health, safety and welfare of the public.

Underlying these tasks were several overarching concerns. The first was the amount of overlap between engineering disciplines regulated in California. The second was whether there were sufficient distinctions between California's practice and title act disciplines to justify maintenance of its existing and unique regulatory structure. The third concern was whether this regulatory structure adequately protects the public health, safety and welfare or, more specifically, whether the practice branches of engineering pose more of a threat than the title branches, thereby justifying the practice/title distinction.

Recommendations for change in California's licensing of engineers are grouped under the appropriate overarching concern. Significant findings from the analysis of educational requirements, examination outlines, pass rates, engineering employment and registration patterns, complaints and insurance claims are summarized under the recommendations they support. Comparisons with ten other states and analysis of the treatment of engineering disciplines in California state and county codes and the Federal Code of Regulations were used to create a context for understanding California's licensing system.

OVERLAP BETWEEN ENGINEERING DISCIPLINES

Recommendation #1a: Remove all prohibitions against overlapping practice between engineering disciplines from the Professional Engineers Act and Board Rules.

Recommendation #1b: Give all regulated disciplines the right to responsible charge of engineering projects when justified by their education and experience.

Supportive Findings:

- California is the only state to specifically allow one-directional overlap of civil into all other disciplines and of electrical and mechanical into the title act disciplines and to prohibit the reverse. Guam is the only jurisdiction besides California that restricts the direction of overlapping practice for some disciplines.

- Education, examination taken and job experience are used to define areas of competence in all states, whether they use generic or discipline-based licensing. With the exception of Massachusetts, all large states and, indeed, most states irrespective of size, use generic licensing. In states with generic licensing, those who have passed the fundamentals and one specialty exam and met the experience requirement may practice any type of engineering as long as they are competent through education or experience. Those challenged through the complaint or legal processes must demonstrate competency. The discipline-based licensing states also define the specialty in terms of the subject matter of the comparable NCEES exam. They differ among themselves in the degree to which they regulate overlapping practice. Rhode Island allows no overlapping practice, while Massachusetts allows engineers to work outside their specialty with Board approval. None of the comparison states, including the two with discipline-based licensing, provided definitions of engineering branches.

- All engineers share a core of support units in physics, chemistry and math. These courses make up between 40% and 55% of all non-general education units required for an engineering degree at Berkeley, Stanford and UCLA, and between 28% and 35% at the CSU campuses. Some engineering disciplines also share engineering course work as well. Manufacturing and metallurgical engineering have many courses in common with mechanical engineering while electrical has very little in common with any engineering discipline, including civil. Failure to share a common educational background undermines the logic of allowing one-directional overlap by civil into electrical engineering while similarities in coursework among manufacturing, metallurgical and mechanical engineers highlights the inconsistency of restricting allowable overlap to mechanical engineers.

- Overlap between disciplines also occurs in the knowledge tested on national licensing exams. Roughly a third of the chemical exam is covered on the breadth and depth modules of the mechanical exam. There is extensive overlap between the manufacturing, control systems and fire protection exams and portions of the mechanical exam and between depth modules on the mechanical and civil exams. Conversely, there is virtually no overlap between any combination of the

electrical and civil exam modules. There is less than 1% overlap between four of the five civil depth modules and the nuclear exam, less than 5% overlap between three of the civil depth exams and the chemical exam, and less than 5% overlap between all three electrical depth exams and the chemical exam.

- In many cases of overlapping exam content, title act disciplines had greater depth in a content area than the practice act disciplines. If the depth measured on the test accurately reflects the skills required in practice, title act engineers may sometimes be the more appropriate choice to serve in responsible charge of a project.

- Three discipline pairs topped the list on both measures of overlap-- the number of shared non-general units in their undergraduate preparation and the exam outlines. These were:

    - Mechanical and nuclear, sharing 52% of education units and an average of 17.7% shared content on the thermal and fluids systems module and nuclear exams.
    - Mechanical and manufacturing, sharing 51% of education units and an average of 31.4% shared content on the machine design module and manufacturing exams.
    - Mechanical and civil, sharing 44% of education units and an average of 21.1% of the machine design and structural depth modules.

- Discipline combinations with the greatest amount of overlap in exam content also had significant numbers of dual licenses. These include: nuclear (15% had a mechanical license), control systems (7% had an electrical license and 5%, a mechanical license), fire protection (7% had a mechanical license and 4% a civil license), metallurgical (4% had a mechanical license), industrial (3% had a mechanical license) and chemical (3% had a mechanical license). Since one-directional overlap and restrictions on responsible charge favor the practice disciplines, dual licenses open up opportunities but increase costs for the title disciplines. The necessity to acquire a practice act license is strong testimony to the economic motivations behind maintaining the practice/title distinction.

- Consistent with the lack of overlap in exam content and the one-directional overlap permitted by the regulatory structure, less than 1% of civil engineers had dual licenses involving the other practice act disciplines and less than 1% of electrical engineers had a civil license as well. Between 1 and 2% of mechanical engineers had licenses in civil and electrical.

- The order in which dual licenses were obtained is also of interest. Of those with dual licenses, a slight majority of the practice act engineers obtained their civil license first (55% and 54% for electrical and mechanical engineers). For the title act disciplines with meaningful numbers of cases, most of those with dual licenses obtained the civil first, ranging from 69% for agricultural engineers to 97% for fire protection. Control systems engineers with electrical and mechanical licenses also obtained the practice license first; 75% obtained the electrical and 53% the mechanical before obtaining the control systems license. The same was true for fire protection and nuclear engineers with mechanical

licenses; 77% and 57% respectively obtained the practice license first. Only chemical engineers obtained the mechanical license second (84%).

- State comparisons suggest that the regulatory structure may be a factor in the pattern of complaints. Massachusetts prohibits overlapping practice without prior Board approval between any of its 46 disciplines while California permits one-directional incidental overlap for civil engineers into any discipline. While the proportion of electrical and mechanical engineers charged with unlicensed activity was similar in the two states (10% and 8% for electrical and 28% and 22% for mechanical in California and Massachusetts respectively), the proportion of civil engineers charged with unlicensed activity was almost four times greater in Massachusetts (12.7% vs. 3.5%).

- Another effect of the regulatory structures in Massachusetts and California can be seen in who gets charged with unlicensed activity. While the proportion of *unlicensed engineers* charged with unlicensed activity was virtually identical in these two states (52.1% in California and 51.9% in Massachusetts), *licensed engineers* in Massachusetts were three times as likely to be charged with unlicensed activity as they were in California (14.2% vs. 4.9%).

- The title act disciplines differ in the proportion licensed since the mid-1970s when six additional disciplines (agricultural, control systems, fire protection, manufacturing, nuclear and traffic) were given title protection. Chemical and petroleum were licensed in 1947, industrial and metallurgical in the mid-1960s. The ten disciplines fall into three distinct groups in terms of licensing activity during the past twenty years. Roughly half to two-thirds of currently licensed chemical, fire protection, traffic and petroleum engineers have been licensed since 1980, proportions comparable to two of the practice act disciplines (civil and electrical with 67% and 65% respectively). Three-fourths of mechanical engineers have been licensed since 1980. Between a fourth and a third of currently registered agricultural, nuclear and metallurgical engineers were licensed during the same period. There has been relatively little licensing activity during this period in control systems, industrial and manufacturing (between 3% and 19%).

- The OES survey indicates that California employs fewer engineers in some of the title act disciplines than many of the comparison states. For example, California and Florida have fewer chemical and materials engineers than any of the comparison states. California has fewer environmental engineers -- a branch counted by OES even though it is not regulated in California -- than all but one of the comparison states, and fewer industrial engineers than seven of the states. It also has fewer mechanical engineers than nine of the comparison states. It is difficult to determine how much of this under-representation is due to the state's industrial profile and how much to its regulatory structure.

- Many of those responding to the questions posed at the Forum on Engineering Licensing 2002 observed that several different types of engineers could perform a large portion of engineering work. For example, permitting for hazardous waste facilities could be done by civil or chemical engineers and issues relating to the flow of liquids through pipes are common to civil, mechanical, nuclear,

chemical and petroleum engineering. There is no reason to limit approval of documents involving the flow of fluids through pipes to civil and mechanical engineers.

- There was general agreement among Forum participants and respondents that solutions to real world problems are multi-disciplinary, a fact recognized by engineering degree programs that include core courses in areas such as material properties, statics, dynamics, thermodynamics, fluid flow, mathematical concepts and electrical theory. Artificially restricting solutions to a single discipline may result in unnecessary costs or in less than optimal solutions.

- In general, complaints against the practice act disciplines come from the public while those against the unlicensed are more likely to come from the Board.[1]

- Most complaints (>70%) against civil, structural and geotechnical engineers come from the public while the source of complaints against mechanical engineers is almost equally divided between the Board (48%) and the public (46%) and allege in equal proportions incompetence (28%) and unlicensed activity (30%). The Board files two-thirds of the complaints against the unlicensed.

Rationale: These findings fail to support the current licensing system's one-directional allowable overlap of civil engineering into electrical, nuclear and chemical, and of electrical and mechanical into the title act disciplines. Currently, civil engineers are permitted to overlap into areas with little or no educational or exam content in common. Electrical engineers, with relatively little exam overlap, may overlap into chemical engineering whereas chemical engineers cannot overlap into mechanical engineering, even though a third of each exam's content is shared with the other discipline. If overlap is permitted where disciplines are extremely divergent, what is the logic for denying mutual overlap when they are more similar (e.g., between mechanical and civil or chemical)? In fact, case law suggests that the treatment of overlap between architecture and engineering -- allowing either discipline to practice in the overlapping areas -- would apply as well to overlap between engineering disciplines (1953 Lehmann vs. Dalis 119Cal.App2d p152). Board practice appears to recognize this since most complaints for unlicensed activity filed by the Board for Professional Engineers and Land Surveyors are against the unlicensed.

There is a similar inconsistency if the Board, in offering comity to migrating engineers, recognizes overlap between unregulated and practice act disciplines through acceptance of education and experience approximating the practice discipline. Where is the logic in denying, for example, Control systems engineers the right to overlapping practice when they have degrees --and often graduate degrees -- in mechanical or electrical engineering?[2] While the Board is recognizing overlap between unregulated

[1] An unknown number of Board complaints reflect referrals from public agencies.

[2] The 1998 Sunset Review Report gives the example of aeronautical engineering (page 35). Since California does not register this branch, an engineer with an ABET-accredited degree, completion of the NCEES aeronautical engineering exam and two years of experience under the supervision of a mechanical engineer would be granted a mechanical engineering license.

and practice act disciplines in one situation, it fails to recognize overlap between the title and practice act disciplines.

There are a number of findings that raise questions about the unique advantage given to civil engineers by the current licensing system -- an advantage that may be distorting the market for engineering services in the state. Although it has been suggested that the high rate of complaints alleging incompetence against civil engineers is due to the fact that they deal more with the public than other disciplines, this is not supported by the data. The number of complaints against civil engineers in relationship to the number lodged against mechanical and electrical engineers far exceeds the ratio of civil to mechanical and electrical engineers who are also employed in consulting services. Moreover, the insurance data indicate that civil engineers are *less* apt to be sued by clients/owners (as opposed to contractors and third parties) and more apt to be sued by third parties than mechanical and electrical engineers. This data also shows that civil engineers do not sustain more claims relative to their exposure in residential construction (the assumed public). Instead, they sustain more claims in areas where they would be dealing with governmental entities. Thus, the excessive number of complaints against civil engineers cannot be accounted for by their concentration in consulting services, the nature of their clients or the type of projects engaged in.

That the current licensing system advantages the practice act disciplines -- and civil in particular -- is also suggested by the source and nature of the complaints. In general, complaints against the practice act disciplines come from the public while those against the unlicensed are more likely to come from the Board. Most of the 2,149 complaints are evenly split between the practice disciplines and the unlicensed, with relatively few (66) involving the title act disciplines -- due perhaps to the limited sanctions that can be levied on those who may practice without licensure and are only licensed for use of a title. California's enforcement focus on mechanical engineers and the unlicensed -- through the filing of complaints for unlicensed activity -- seems to serve the function of protecting the boundaries of civil engineering. Since parts of mechanical and civil engineering share both educational background and exam content, overlapping tasks are to be expected and should be allowed in both directions. Massachusetts, a state allowing no overlap between any engineering disciplines, appears to maintain boundaries between disciplines in all directions, as indicated by the higher proportion of complaints against licensed engineers charged with unlicensed activity (14.2% vs. 4.9% in California) and by the higher proportion of complaints of unlicensed activity against civil engineers in that state (12.7% vs. 3.5% in California). California primarily charges disciplines other than civil engineering with unlicensed activity.

Does allowable overlap encourage civil engineers to over-reach their areas of competence, increasing the number of complaints? Does the restriction of responsible charge place civil engineers, sometimes inappropriately, in charge of projects beyond their area of competence? The broad nature of civil engineering may encourage this tendency. The fact that the proportion of civil engineers charged with unlicensed activity is almost four times higher in Massachusetts than in California suggests that allowable overlap in California suppresses official reaction to involvement outside the civil engineer's area of expertise.

Although the use of licensing to gain competitive advantage is a frequent observation in the literature, it would not seem to be in the public interest for this to be maintained in the

licensing of engineers in California. All engineers have made a considerable investment in establishing their educational credentials. Title act engineers in disciplines that overlap with some part of civil or mechanical engineering are currently limited in their ability to benefit from that investment -- a restriction of trade that would not seem to be justified by differences in educational preparation or exam content. Although the hierarchical nature of responsible charge is ambiguously stated in the Engineers Act and Board Rules, letters and actions representing the Board's position have reinforced the idea that only the practice disciplines may be in responsible charge of engineering activities. Forum participants provided numerous examples of the limitations on their professional opportunities caused by this unique feature of California's regulation of engineering. (See Appendix I for the experience of a chemical engineer licensed in California, Arizona and New Mexico that illustrates the impact of California's responsible charge restrictions on the individual, the potential client and the quality and cost of engineering performed in the state.) Limiting responsible charge to the three practice disciplines restricts the search for engineering solutions to those within the competency and knowledge base of those disciplines when the optimal solution may depend upon scientific knowledge from other engineering specialties.

A January 9, 2002 article in *The Sacramento Bee* illustrates the benefits of being able to explore alternative approaches to a problem. On the government's Superfund list of most polluted sites in the country, Aerojet is seeking other solutions to the pumping and treatment of ground water contaminated by perchlorate, an ingredient of solid rocket propellant. The company's environmental engineers are now experimenting with in-place bioremediation as a quicker and less expensive replacement for the pump-and-treat system that has been in place since the early 1980s at a cost to Aerojet of $184 million.

Several participants felt that rapidly changing technology, from biomedical to software engineering, makes it even more critical that the most qualified person, regardless of discipline, be in responsible charge. With backgrounds in the biological or computer sciences and projects totally unrelated to the built environment, engineers in newly developing specialties may eschew licensing or seek exemption for their industry to avoid inappropriate supervision of their work. Moreover, it is in society's interest to consider alternate approaches to problem solution and to let social values and economics determine the ultimate approach.

The restriction of responsible charge (Article 3, section 6730 and 6730.2) to the three existing practice act disciplines may undermine protection of public health, safety and welfare and may be weakening the title act disciplines in the state. Relatively few have taken exams in some of the title act disciplines since they were initiated in the 1970s -- perhaps because they are employed by corporations where licensing is not an issue, or perhaps because they have taken the closest practice discipline exam. Only 3% of those licensed in Manufacturing have been licensed since 1980, 12% of those in Control Systems and 19% of those in Industrial. In addition, the OES survey indicates that California employs fewer engineers in some of the title act disciplines than many of the comparison states. Thus, there is a suggestion that one-directional overlap favoring civil engineering and the restriction of responsible charge to the practice disciplines has combined with the growth of industrial exemptions to weaken the title act disciplines in the state.

Forum participants noted that the hierarchical nature of responsible charge also distorts the licensing process because engineers in the more specialized and less powerful branches seek licensing in the practice branch closest to their specialty. The combination of disciplines with dual licenses supports this argument to some degree. A third of traffic engineers and a fifth of agricultural engineers also have a civil license, while 15% of nuclear engineers and half that many fire protection engineers have mechanical licenses. Control systems engineers with two licenses are divided between electrical (7%) and mechanical (5%) licenses.

The determination of allowable overlap in a technologically complex, rapidly changing set of disciplines is not practicable by a professional, political or disciplinary group. In general, licensed professionals should operate within the area of their education, training and examination, as currently specified in Board Rule 415. They and those who employ them should be held accountable for the use of their skills in an applied setting. Professionals operating outside of their area of expertise would be held accountable if they overreach their area of expertise, resulting in a complaint, lawsuit or insurance claim. The alternative to permitting overlap based on education, exam and experience is for the Board to approve overlap on a case-by-case basis -- a task that seems cumbersome in a large state and not the best use of the Board's efforts. The resources focused on overlap and protecting the interests of a single discipline could be better employed to protect public health and safety.

Recommendation #2: Eliminate title protection and offer practice protection to all regulated disciplines.

Supportive Findings:

- No other state allows the unlicensed practice of regulated engineering disciplines. The licensing of title use rather than practice in all branches of engineering except the three practice act disciplines (civil, electrical and mechanical) and their related title authorities (structural and geotechnical) is unique to California.

- The review of federal, state and county codes indicates that several title act disciplines are referenced (chemical, fire protection, petroleum, and traffic). Prescriptive statements in the state and local codes -- requiring, for example, that fire protection and traffic engineers stamp plans -- indicate that state and local agencies recognize that skills held by persons with this training are important to decisions affecting the public health, safety and welfare. In effect, these prescriptive statements establish "de facto" practice disciplines, although in an uncoordinated manner within various state and county codes.

- In contrast to the emphasis on practice disciplines, and especially civil, in the California Code of Regulations, the Federal Code of Regulations primarily references "registered or licensed professional engineers," independent of discipline.

- A 1990 decision by the Office of Administrative Law (Docket No. 89-009) found that the Board's policy of prohibiting fire protection engineers from performing design services and designing fire protection systems was a "regulation" that needed to be adopted in compliance with the Administrative Procedure Act if fire protection engineers were to be excluded from offering design services. The decision notes that definitions for five of the title acts (agricultural, chemical, industrial, nuclear and petroleum) include the performance of design services, yet communication of Board policies indicates that only the practice act disciplines may engage in design services.

- There are no systematic differences in registration rates between practice and title disciplines. One practice discipline, civil, had one of the highest rates, while another, electrical, had one of the lowest. Registration rates for title act disciplines were found throughout the range. Among the title disciplines, agricultural, chemical and nuclear have among the highest rates (88% and above), while materials/metallurgical and industrial have some of the lowest (18% and below).

- Consulting directly to the public is not a justification for distinguishing practice and title act disciplines since there were no systematic differences in employment location between them. Most electrical and title act engineers are employed by private corporations. More mechanical, chemical and "other engineering disciplines" are in engineering and architectural services than is the case for

electrical engineers. Although there are more civil engineers in engineering and architectural services than any other discipline (38%), a majority (56%) of civil engineers work for the government.

- Considering the ratio of registered civil, mechanical and electrical engineers employed in engineering and architectural services, proportionately more complaints are filed against civil engineers (including traffic, geotechnical and structural) than mechanical or electrical engineers. While registered civil engineers in E&A services outnumber mechanical engineers 6.5 to 1 and electrical 35.5 to 1, the number of complaints against civil engineers outnumbers mechanical 25 to 1 and electrical, 55 to 1.

- Civil engineers are also over-represented, and electrical and mechanical engineers under-represented, among those who are the subject of insurance claims -- relative to their proportions in the engineering work force. None of the three are over-represented in proportion to client fees generated by the firms involved in claims, although structural engineers are.

- The nature of the client does not explain differences in claims experience. Fewer civil engineers are sued by client/owners (51% vs. 72% and 60% for mechanical and electrical) and more are sued by third parties (33% vs. 13% and 21% for mechanical and electrical).

- The type of projects involved in also does not explain discipline differences in claims. Different project types engaged in by a single discipline can generate positive and negative claims/fee ratios and the same project type engaged in by multiple disciplines can generate different claims/fee ratios for the separate disciplines. For example, civil engineering firms had positive ratios for their work on roads and highways, generating fewer claims and claim dollars than they earned in fees, but a negative ratio for work on wastewater, sewage and water treatment systems. Civil engineering firms engaged in residential projects came out even -- generating similar proportions of claims and fees -- while, for electrical engineers, residential projects were much more damaging -- generating six times the number of claims as fees.

Rationale: The finding of extensive overlap between the disciplines raises the question of whether distinctions between the practice and title disciplines outweigh their commonalities, and in doing so justify their separate regulatory status. One-directional overlap between practice and title disciplines, the responsible charge hierarchy, and the unlicensed practice of regulated disciplines are what makes California's licensing system unique. This system appears to have grown out of its geopolitical environment. Historically, water projects, highways and high-rise buildings have defined the state's growth and showcased the remarkable achievements of its civil engineers. Their position as the first licensed engineering discipline in California and their contributions to the infrastructure had a significant effect on the profession's development within the state. The introduction of other engineering disciplines with title rather than practice protection was an early indication of the competitive struggle over professional turf that continues half a century later. The intervening years have brought a growth in scientific knowledge and technology unimagined when the Professional Engineer's Act was first written. Although infrastructure is still important, other scientific disciplines and their

engineering applications have contributions to make to the state's economy and its public works. The question underlying the Title Act study -- and most evaluations of licensing in the literature -- is whether regulation serves the economic interests of powerful members of a profession or the public health, safety and welfare of the state's citizens. In particular, the question is whether there is sufficient justification for making regulatory distinctions between the practice and title disciplines.

Many of the findings fail to support this distinction. In seeking a rationale for the practice/title distinction, ISR explored whether most consulting with the general public is done by practice disciplines. Although the proportion of civil engineers in "engineering and architectural services" is higher than other disciplines, electrical engineers are less likely to consult directly with the public than mechanical, chemical and "all other disciplines." Thus, if consulting directly with the public were the basis for practice protection, electrical engineering would be a title act and mechanical, chemical and "all other disciplines" -- along with civil -- would be practice acts.

However, the proportion in consulting is not the only important consideration. There is the assumption that the "public" the civil engineers are dealing with is somehow different from that of the other disciplines. Some would argue that civil engineers' consumers lack the knowledge necessary to decide who is competent or has the background necessary for a given project. Although the claims data describes only a portion of the client base, what's available does not support this perception. The claims/fee ratios show that civil engineers involved in residential construction have more positive ratios (e.g., fewer claims than exposure would lead one to expect) than those involved in wastewater, sewage and water treatment systems (e.g., more claims and claim dollars than fees collected). One would expect more "naïve consumers" in the former type of project than the latter, but they do not seem to be filing an inordinate number of claims. Instead, claims against civil engineers were filed by public agencies.

The client/consumer is only one small part of the public affected by engineering work. As the introduction to the Agricultural Job Analysis Questionnaires put it: "the public includes all individuals, groups and community interests, including employees, clients, plant and animal systems, and community environmental interests that could be harmed through incompetent practice." In the claims data, compared to structural and other practice act engineers, civil engineers were much more likely to be sued by third parties.

Another finding that fails to support a distinction between practice and title disciplines is the lack of systematic differences in registration rates between the two. It has been suggested that the small numbers of engineers registered in the title act disciplines might be an argument for deregulating all of them. What is important is the registration rate, the number of registered engineers relative to the number employed in a discipline. This measure shows no systematic differences in registration rates between practice and title disciplines. Some of the title acts have higher registration rates than mechanical engineering, while electrical has the lowest rate of any discipline. Using registration rates as the basis for deregulation would suggest deregulating electrical along with the title disciplines with low registration rates.

A third set of findings tests whether involvement in complaints and insurance claims vary by discipline. If complaints are indicators of threats to the public health, safety and welfare, then civil engineers constitute more of a threat than mechanical and electrical engineers, even when registration and involvement in engineering and architectural

services is taken into account. Similarly, relative to their proportion of the labor force, civil engineers are also over-represented, and electrical, mechanical and all other engineers under-represented, among those who are the subject of insurance claims. If threat to public health, safety and welfare were the main justification for licensing, then -- using these indicators -- only civil engineers would be licensed.

The problem in using these indicators is that they may not accurately reflect the potential for harm posed by other disciplines. Since the Board has no significant authority over title act disciplines, there is little motivation to lodge a complaint with the Board. If most title act engineers are employed by private industry and their errors are theoretically redressed through legal actions unknown to the public, we really have no measure of the degree of threat posed by these disciplines.

In sum, if all of the other states, discipline-based or generic, acknowledge the equality of all regulated disciplines, what justification could there be for California's unique regulatory system? The extensive overlap and the lack of consistent differences between the practice and title act disciplines argues strongly for eliminating the regulatory distinction and licensing all disciplines with practice protection.

Recommendation #3a: The Board of Professional Engineers and Land Surveyors should track engineering degrees, examinations taken (including the depth module where appropriate) and job experience at time of application for licensing as a means of identifying areas of expertise and assessing policies associated with exam administration. Limited information on licensees should be available to the public.

Recommendation #3b: If the justification for licensing is protection of public health, safety and welfare, and if the state recognizes engineering as a field with the potential for significant social harm, then the state should accept the responsibility of maintaining useful records on applicants for licensure and complaints against licensees so that evaluative questions can be asked of the data.

Supportive Findings:

- Among the comparison states, California has the lowest pass rates on the fundamentals exam, the civil breadth exam, the transportation and water resources depth exams, and, in four of the five years, the electrical exam.

Rationale: While California's tracking of data on the licensing and disciplining of engineers is better than what ISR was able to obtain from its comparison states, the limited resources assigned to these functions in all of the states studied undermines accountability to the public. Although tracking applicant background and exam performance for internal analysis would add to the Board's responsibilities, it would improve accountability to the public and the profession. At a minimum, degrees and their specializations, the university granting the degree, qualifying job experience, and primary language should be in a file with scores on the exams taken. If applicant background information were kept in a single database linked to exam performance, it would be possible to assess what backgrounds were associated with success or failure on the exams. Educational backgrounds associated with success on the exams could be summarized for the benefit of those seeking licensing. In addition, this information could be used to understand the reasons for California's performance on the fundamentals, civil and electrical engineering exams. It would also be possible to determine whether the "special civil" requirement places an unusual burden on those seeking licensing in portions of civil that are less involved with the built environment (e.g., environmental and water resources).

This licensee data should also be linked to data files summarizing complaints and their outcomes. This would allow an analysis of the backgrounds of engineers generating complaints and their outcomes. Currently, complaint outcomes are not adequately captured in the database. Ultimate disposition after referral to another agency and disciplinary actions taken (suspensions, probation, revocation of license, fine) are not included. The inability to link licensee background and complaint data and the quality of the complaint variables limits the ability to analyze patterns of relationships between factors associated with incompetent practice and outcomes. For example, this type of analysis could be used to inform policy by examining whether the outcomes are appropriate to the problem and whether recurring problems are associated with a

particular discipline. A licensing system that is accountable to the public should maintain records that permit the identification of problems in a regulated discipline and the assessment of whether the complaint and legal processes are adequately protecting the public.

Tracking professional training could also benefit the public as well as potential clients and employers. Currently, California's constitution protects the privacy of a professional's educational preparation. Civil Code 1798 of the Information Practices Act restricts the information that can be disclosed to the registration and license number. This does not appear to be in the public's best interest. At a minimum, potential clients and employers should be able to confirm an engineer's degree and areas of specialization, the university granting the degree and the licensing examination completed as general indicators of the individual's competencies.

Recommendation #4: The legislature should mandate the reporting of legal actions, including out-of-court settlements, against engineers, licensed or unlicensed, and against corporations engaged in engineering activities, to the Board.

Rationale: Similar to medicine, but on a larger scale, engineering activities have the potential for significant harm to large numbers of people. According to Forum participants and respondents, incompetent practice of most engineering disciplines would be harmful. In medicine, there appears to be more accountability. Errors are reported by hospitals and legal actions are reported to licensing boards. Engineering lacks a parallel reporting system. Mandated reporting would provide information on the potential for harm in exempt industries, and among unregulated disciplines and licensed engineers. If health and safety impacts are the major rationale for licensing, this information could be used to decide which engineering disciplines needed to be regulated. The widespread use of exemptions from licensing in California and its comparison states may undermine the public health, safety and welfare. There is less accountability in a regulatory system that registers less than half of the states' engineers. The frequency of recalled products (e.g., automobiles) and industrial contamination of the environment suggests that dependence upon the courts for after-the-fact redress of harm fails to protect public health, safety and welfare. Relying on employing industries to ensure competent practice places the public health, safety and welfare in competition with the private sector's focus on profit.

A March 23,2002 article in the *Sacramento Bee* illustrates the kind of outcome that can occur when public health and safety concerns conflict with the economic interests of an industry. The article reported that two-thirds of a sample of 150 upgraded gasoline storage tanks in four California counties leaked both gasoline and toxic fumes. Extrapolated statewide, "the findings would suggest that as many as 32,000 of the state's 48,000 underground fuel storage systems are leaking vapors." William Rukeyser, Cal-EPA spokesman, noted that "When technicians designed the upgraded systems and legal requirements were put in place, the focus was on liquid leakage…We've investigated further, and it has become obvious they did not focus on the question of vapor loss." Firms required to incur costs to reduce public health threats caused by their industry's activities may construe the requirement in the narrowest terms. Errors of omission by design technicians, or a management decision to disregard engineering recommendations if the solution is too costly, result in significant social costs and a lack of accountability by the engineers involved. These threats to public health, safety and

welfare are not captured by the complaints and claims data described in this report and there are no publicly available records of the frequency with which these types of engineering activities threaten the public.

Broader involvement in licensing may add more professional weight to advocates for sound engineering practices in industry. A parallel process has occurred in medicine where the licensing of physicians assists them in asserting standards of practice -- although changes in the organization of medicine may be weakening this power. Some Forum participants thought that broader involvement in licensing would strengthen their position within industrial and governmental bureaucracies when other organizational interests conflict with the engineers' best practices recommendations. Licensing, as a state function, should support regulated disciplines in the maintenance of high professional standards and protect the public through establishing minimum levels of competence independent of job setting. Engineers should be given both the protection and the responsibility of licensing. In medicine, we hold both physicians and their employers accountable. If engineering offers the potential for significant harm, why would we not do the same when engineering principles are violated and the public is harmed?

While many exempt engineering activities may be harmless, and the current licensing system's restrictions sufficiently onerous as to discourage industry's use of licensed engineers, part of the difficulty may lie in the intrusion of an inappropriate hierarchy of responsibility represented by the practice/title distinction and the rule of responsible charge. If, as Forum participants argued, all engineering disciplines affect the public health and safety, then there is something illogical about widespread exemptions -- unless there is substantial regulation of the exempt industries whose activities threaten public health and safety. There is also something illogical about applying exemptions to all disciplines except civil unless there is strong evidence that this discipline constitutes more of a threat than any other. The claims data does not support making a distinction between civil and the other practice and title disciplines. With the exception of structural, all of these disciplines make up a smaller proportion of claims and claim dollars than their percentage of client fees collected.

The reporting of legal actions against engineers would provide the data necessary to determine whether disciplines, regulated and unregulated, really differ in their potential for harm and whether exemptions actually have an effect on public health and safety.

Recommendation #5a: Develop better information on the public health, safety and welfare impacts of engineering branches before making regulatory distinctions between them. Only when legal actions are reported and more comprehensive complaint data and insurance premium and claims data are available can the state determine whether there is any justification for deregulating currently regulated disciplines. Current information relevant to the Sunrise criteria supports extending practice protection to all currently regulated disciplines. If stronger data becomes available, the need for continuing regulation can be evaluated at that time.

Recommendation #5b: Accept as new regulated disciplines those with an NCEES or California-developed examination if their assessment under the Sunrise Criteria is comparable to existing regulated disciplines.

- Degree programs and specializations exist for all practice and title act disciplines. (Sunrise criteria VIII)
- NCEES job analyses identify the knowledges, skills and abilities required for nationally regulated disciplines and California's Office of Examination Resources provides similar profiles for several disciplines where NCEES exams are lacking or insufficiently reflective of the discipline's practice in this state. Summaries based on the job analyses measure degree of consensus on what skills define a discipline. Both sets of exams, built on the job analyses, measure minimum competence in all of the practice and title disciplines regulated in California. Consensus on the skills encompassed by a discipline and the measurement of minimum competence respond to questions included within Sunrise criteria VI and VIII.
- Most of the comparison states use the existence of an NCEES exam to recognize specific engineering disciplines. (Sunrise criteria III)
- There is not enough publicly available data to objectively address some of the Sunrise criteria questions, particularly those in criteria I, II and III.

Rationale: California determined in the early part of this century that the engineering profession should be regulated to protect the public health, safety and welfare. In the 1990s, the Sunrise criteria were introduced to provide more systematic guidelines for determining what occupations should be licensed. The current regulatory structure for engineering appears to treat the various branches of engineering as separate occupations, expecting each branch to justify practice protection independently. However, existing data provides inadequate information to answer the questions posed under several Sunrise criteria for any engineering disciplines and fails to support the current regulatory distinction between the practice and title branches. If recommendations 2 through 4 were in place and if the state could obtain the information, then insurance claims and premiums data, reported legal actions, and future complaints against fully licensed engineering disciplines could be used to decide whether some branches no longer required regulation and whether emerging branches justified it.

In compiling this report, ISR could only obtain very limited information from the insurance companies. If the state were able to obtain data on the varying costs of insurance coverage and the number and cost of claims by engineering discipline, this could be one of the best indicators of the effect different branches have on public health, safety and welfare. The claims data made available to ISR only described claims against

engineering firms, which employ a minority of engineers. The state would want to determine whether the costs of insurance held by industries and agencies engaged in engineering activities and employing the majority of engineers could be identified with the work of specific engineering disciplines. If insurance premiums and claims data tied to particular engineering branches were available for exempt industries and public agencies, this information could be used to decide whether some branches have so little impact on public health and safety that registration would not be required and that others perhaps should not be exempt.

In addition, mandated reporting of legal actions against exempt companies and agencies hiring engineers and producing engineered products and services would be a necessary complement to the insurance data. Legal actions would measure threats in the broadest arena of engineering activity. The challenge in using insurance and legal data would be the difficulty in assigning responsibility for actionable incompetence or negligence to practitioners of specific engineering disciplines. The extent of overlap between disciplines and the subsuming of emerging disciplines within older branches, such as environmental within civil engineering, could make assigning responsibility for errors difficult.

Finally, the state's complaint data would provide a more complete picture of incompetent practice by discipline if all regulated branches were practice acts and subject to the same sanctions. Under the current regulatory structure, there is little incentive to file complaints against title act engineers because of the limited sanctions available. Therefore, the number of such complaints probably understates their potential for harm.

Thus, in order to decide which disciplines should continue to be regulated as practice disciplines, or which new ones should be admitted to practice protection, the state would need access to insurance and legal data not currently available and it would need more detailed complaint data on all existing disciplines after practice protection had been extended to include the current title disciplines. Without this crucial information, there is no basis for recommending that any disciplines be deregulated.

In fact, information developed in this report provides significant reason to recommend that all of the disciplines be retained with practice protection. The report shows that job analyses identify defined tasks for the separate disciplines, and that while overlap in education and exam content exists between some discipline pairs, they are distinguishable from each other. The regulated disciplines are taught in engineering schools and their knowledges and skills are testable using NCEES and California exams. The comparison states do not distinguish California's practice and title act disciplines in their licensing structure. They require a similar education and experience background and recognize passage of an NCEES exam as the route to generic or discipline-based licensure. Thus, there are no systematic differences between practice and title disciplines on those Sunrise criteria for which information is available.

Recommendation #6a: California's legislature, Board and engineering organizations should work closely with NCEES to standardize the goals, methodologies and analytical techniques used in its job analyses across all engineering disciplines.

Recommendation #6b: Both California and NCEES should maintain non-proprietary data files describing the job analyses to assist educators and licensing boards in understanding and tracking changes in the field.

- The current job analyses vary in the goals, methodologies, and analytical techniques used by the separate disciplines in their survey design. Some disciplines provide a very brief and general description of important tasks and knowledges in their discipline, while others seek to provide a more extensive and detailed description of their field. Most focus on the more common tasks performed by practitioners in their discipline; one discipline (manufacturing) omits the more common tasks and focuses on less widely shared tasks in newly developing or unusual applications of the discipline. The surveys differ in the measurement of educational background and job experience and in whether unlicensed engineers are included in the sample. Published reports on the results vary in the descriptive statistics used and in how the sample is grouped for analysis. Some describe the sample as a whole while others describe only subgroups within the sample. Most disciplines do not profile the variations in tasks in different job settings or in exempt or non-exempt employment, or by engineers with different levels of experience.

- California's Office of Examination Resources does not maintain job analysis data files that support examinations currently in use. It also does not report important descriptive statistics, specifically the standard deviations, which would allow an assessment of the degree of agreement on task frequencies and criticality.

Rationale: California's Legislature, Board and engineers have a shared interest in improving NCEES' job analyses that are used to develop its exams. Since disciplines vary in the proportion registered and job analyses differ in the degree to which they take licensing status and job setting into account, the exams based on them do not present a complete picture of the various engineering disciplines. If licensing exams are taken early in an engineering career, following completion of the required experience, examinees may not know whether they will find employment in exempt or non-exempt settings. To the extent that advances in engineering occur in exempt industries, recent engineering graduates with training in some of the new technologies may be unable to pass an exam based on more traditional content that reflects what registered engineers employed in non-exempt industries do. A lack of fit between the exam and the discipline as it is practiced in a variety of settings would increase failure rates, especially in those states where technological advances are being made.

Without underestimating the difficulties involved, engineering would benefit from not only coordinating sampling methods, but also standardizing the design of job analysis instruments across all disciplines and from a more sophisticated analysis of variations in tasks by licensing status and job setting that would link the exams more closely to the population taking them. Greater standardization in the methodologies of job analyses would make the resulting exams more equivalent as tests of competence in multiple engineering disciplines and would increase the usefulness of the job analyses in the assessment of overlap, a feature of importance to licensing boards. The lack of standardization prohibited the use of job analyses for this purpose in the current study.

If the job analyses are important to the profession, state legislatures and licensing boards for their separate purposes, then NCEES and California's Office of Examination Resource should retain all job analyses data files for historical purposes. Although the most recent data collection is used to update the exams, earlier job analyses could be used to track changes in the field.